Korean VLBI Network:
the First Dedicated Mm-Wavelength VLBI Network in East Asia

Kiyoaki Wajima, Hyun-Goo Kim, Seog-Tae Han, Duk-Gyoo Roh, Do-Heung Je, Se-Jin Oh, Seog-Oh Wi, and Korean VLBI Network Group

Korea Astronomy and Space Science Institute, 61–1 Hwaam-dong, Yuseong, Daejeon 305–348, KOREA
E-mail: kiyoaki@trao.re.kr

Abstract

Korean VLBI Network (KVN) is the first dedicated mm-wavelength VLBI Network in East Asia and will be available from the middle of 2008. KVN consists of three stations and has the maximum observation frequency of 129 GHz with the maximum baseline length of 480 km. KVN has unique characteristics in the multifrequency, simultaneous observing system. By taking advantage of this we are considering various science topics, including not only maser emitting regions and young stellar objects in our galaxy, but also extragalactic objects. Construction of the first site is in progress. We are concurrently developing components, including receivers, data acquisition systems, and a correlator, and also arranging the international collaboration.

INTRODUCTION

KVN is the first VLBI facility in Korea [1]. KVN consists of three stations, Seoul (Yonsei Univ.), Ulsan (Ulsan Univ.), and Jeju (Tamna Univ.) and has the maximum baseline length of 480 km (Seoul – Jeju) with the maximum observation frequency of 129 GHz (see Fig. 1). The maximum angular resolution of KVN is therefore 1 milliarcsecond (mas). This frequency is the highest one among dedicated VLBI facilities around the world.

The antenna has a diameter of 21 m and can perform a fast-switching (3 deg $\sec^{-1}$ in Az, El) to enable phase-referencing VLBI observations and superposition of different frequency images.

KVN employs unique observing system. KVN has simultaneous reception system up to four frequency channels, 22, 43, 86, and 129 GHz. In order to ensure this, three frequency selective surfaces (FSSs) are used in the quasi-optics system (see Fig. 2). Dual frequency receiver at 2 and 8 GHz is also equipped for geodetic observations. Dual polarization reception will be available at whole observation frequencies.

KVN will be constructed with two-term planning. In the first stage (2001 – 2007), fundamental construction of each site, installation of the antenna and the data acquisition system, and receivers for 22 and 43 GHz will be carried out and test observations will be performed in order to estimate the capabilities of the whole observing system at lower frequencies. Receivers at 86 and 129 GHz will be installed in the second stage (2008 – 2010). KVN correlator project is also ongoing concurrently with the KVN project with 5-year mission since 2004.

SCIENTIFIC TARGETS

By taking advantage of the unique system, mentioned in the previous section, we are considering various scientific targets. In evolved stars and star forming regions, which are main targets in KVN observations, we intend to study physical relations between formation and pulsation driven shocks and SiO pumping mechanisms by observing H_2O and SiO masers simultaneously. KVN covers three SiO maser lines with different rotational transitions, simultaneous observation of these emissions is therefore essential to study pumping mechanism of SiO maser. Young stellar objects (YSOs) will also be a key target in order to study magnetosphere structure by monitoring multifrequency flux densities to detect flare features.

Simultaneous reception system will also be a good one to reveal parsec-scale accretion processes of warm gas in active galactic nuclei (AGNs). In nearby galaxies, KVN will be able to distinguish free-free absorption from synchrotron self absorption in the jets of AGN. H_2O megamasers are also important targets and the position of maser spots will be precisely determined with respect to a continuum emission by using KVN.

Not only various scientific targets but also geodetic VLBI observations will be performed on the international collaboration.

Site name	Longitude [° ′ ″ E]	Latitude [° ′ ″ N]	Altitude [m]
Seoul	126 56 35	37 33 44	260
Ulsan	129 15 04	35 32 33	120
Jeju	126 27 43	33 17 18	320

Site name	Baseline length [km]		
	Seoul	Ulsan	Jeju
Seoul	—	305.2	477.7
Ulsan	—	—	358.5
Jeju	—	—	—

Figure 1: Location of KVN sites. Site position paramters and baseline length between each station are also listed.

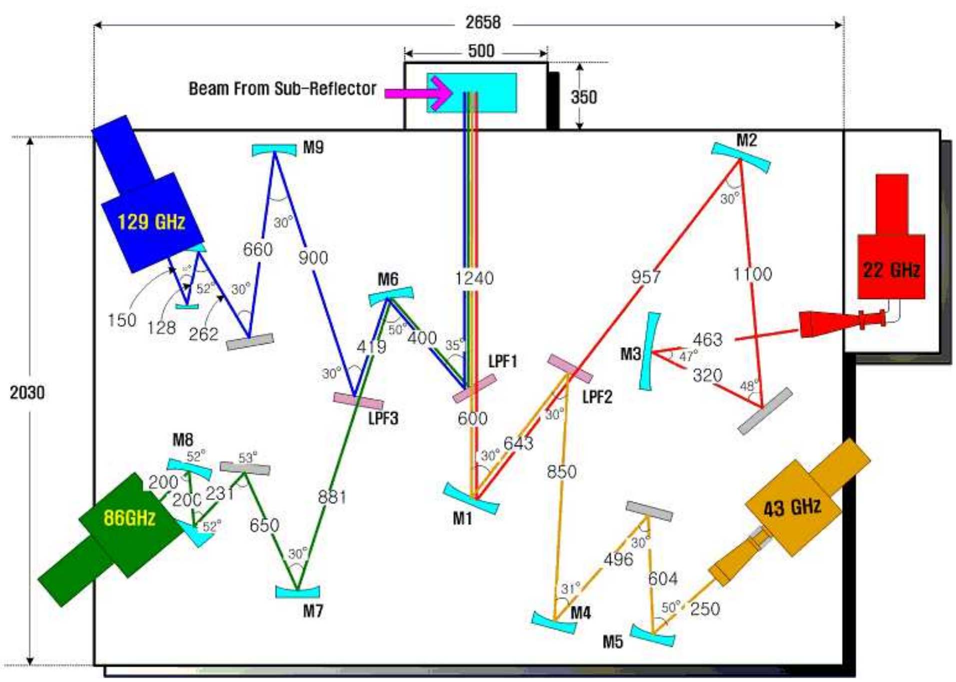

Figure 2: Quasi-optics system of KVN.

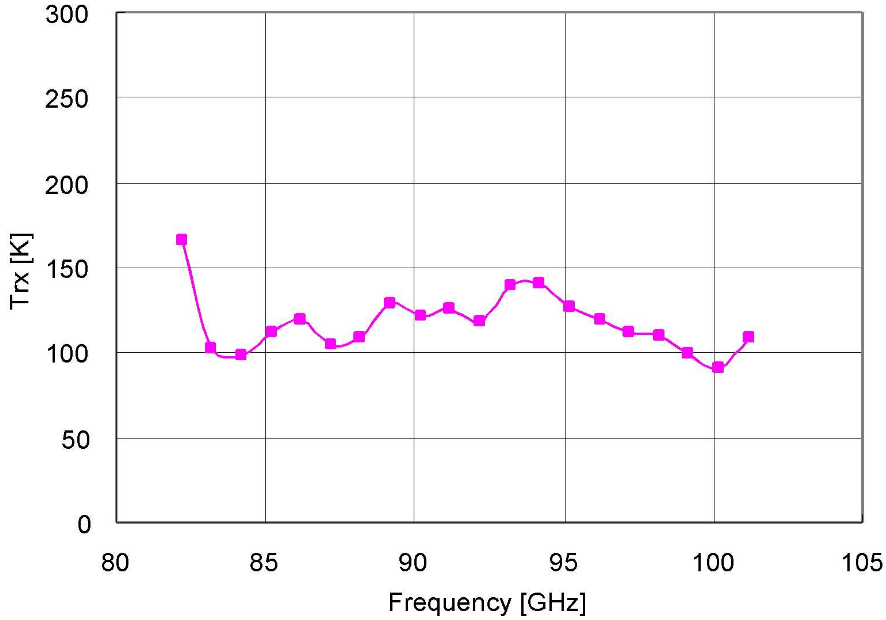

Figure 3: Measurement result of the receiver noise temperature at 86 GHz developed by KASI.

SITE CONSTRUCTION AND DEVELOPMENT OF COMPONENTS

Fundamental construction of the first site (Ulsan) started from the last December and is in progress. The second (Jeju) and third (Seoul) sites will be started construction by the end of 2005 and the middle of 2006, respectively. We have already made a contract and completed the detailed design of the antenna. The antenna installation at Ulsan site will start from the early 2006 and completion of installation at all the three sites will be in the middle of 2007.

Development of MMIC HEMT amplifiers is in progress for observations at 22, 43, and 86 GHz. The receiver noise temperature ($T_{\rm rx}$) for each frequency is typically 65 K (43 GHz) and 120 K (86 GHz) and those have sufficient performance as expected (see Fig. 3). We will perform further improvement of those amplifiers, and start development of an SIS mixer for 129 GHz observations in 2007.

A design of the data acquisition system (DAS) has already completed. Four 1-Gsps samplers are equipped and observed data at each frequency are digitized in the data rate of 2 Gbps. A digital filter is installed in order to accommodate various observation modes by simultaneous receiving system. The data are recorded by the Mark 5B recorder developed at MIT Haystack Observatory [2]. Hardware connection and data transmission of almost all DAS equipments are compliant with the VLBI Hardware Standard Interface (VSI-H).

The KVN correlator project is ongoing and we are currently studying required functions and how to carry out the program. We plan optical fiber connection of each KVN site in the future in order to realize e-VLBI observations, and we are discussing the possibility with domestic communication companies.

INTERNATIONAL COLLABORATIONS

As stated in the first section, we have already started international collaboration in parallel with the site construction of KVN.

In 2002 VLBI collaboration agreement was concluded between Korea Astronomy and Space Science Institute (KASI, former Korea Astronomy Observatory) and National Astronomical Observatory of Japan (NAOJ). On the basis of the agreement, we have already started discussion on the future collaboration for joint observations between KVN and Japanese VLBI network, VERA (VLBI Exploration of Radio Astrometry), and on science and technology exchange. We have already succeeded 86 GHz VLBI observations between Taeduk 14 m – Nobeyama 45 m baseline toward SiO maser emission in VY CMa [3]. This is the first detection of SiO maser emission at 86 GHz toward this source. We are planning further VLBI observations for drawing up future joint observations.

The standing committee for the coordination of the East Asia VLBI Consortium, including Korea, Japan, and China, was established in order to discuss the future collaboration and to organize the East Asia VLBI network (EAVN) [4]. EAVN will be organized up to 16 radio telescopes in each country, and KVN and VERA will become core stations in this array.

KASI and NAOJ have made an arrangement for development of the VLBI correlator. The correlator is mainly designed for joint observations with KVN and VERA, while current correlator design involves a sufficient number of stations and wide delay tracking window so that correlation for observations of EAVN and the next Space VLBI mission, mentioned below, can be performed. The correlator will be installed at the KVN site in Seoul and completed on 2008.

We are also considering to participate the next Space VLBI (VSOP-2) mission [5], [6] as a ground counterpart and data processing work by a correlator above mentioned. KVN and VERA will be one of the important ground stations for the VSOP-2 mission because all radio telescopes including VSOP-2 spacecraft furnish with the dual polarization receiving system at 22 and 43 GHz and the fast-switching function.

CONCLUDING REMARKS

KVN is the first dedicated mm-VLBI facility with an observing frequency up to 129 GHz. The KVN project is well under way thanks to collaboration with a lot of institutes and companies around the world. It is our wish to make many observations not only by KVN but also with VLBI facilities around the world and produce many scientific results. You can find the up-to-date information on the KVN and related projects via Internet (http://www.trao.re.kr/~kvn/).

ACKNOWLEDGMENTS

K.W. acknowledges support from Korea Science and Engineering Foundation (KOSEF).

REFERENCES

[1] Y. C. Minh, D. -G. Roh, S. -T. Han, & H. -G. Kim, "Construction of the Korean VLBI Network (KVN)," in *ASP Conf. Ser. vol. 306, New Technologies in VLBI*, ed. Y. C. Minh (San Francisco: ASP), pp. 373–381, 2003.

[2] A. Whitney, " The Mark 5B VLBI Data System," in *Proc. 7th EVN Symp.*, pp. 251–252, 2004.

[3] K. M. Shibata et al., "First mm-VLBI Observations between the TRAO 14-m and the NRO 45-m Telescopes: Observations of 86 GHz SiO Masers in VY Canis Majoris," *Publ. Astron. Soc. Japan*, vol. 56, pp. 475–480, 2004.

[4] M. Inoue, "East Asia VLBI Consortium and Its Committee," *J. Korean Astron. Soc.*, vol. 38, pp. 77–79, 2005.

[5] H. Hirabayashi et al., "The VSOP-2 Project: A Second Generation Space-VLBI Mission Ranging to mm-Wavelengths," in *Proc. SPIE Int. Soc. Opt. Eng.*, vol. 5487, pp. 1646–1656, 2004.

[6] Y. Murata, "Space VLBI Project," *J. Korean Astron. Soc.*, vol. 38, pp. 97–100, 2005.